TWO YEARS OF OPERATIONAL AIR QUALITY FORECASTING WITH GEM-MACH15: PERFORMANCE EVALUATION

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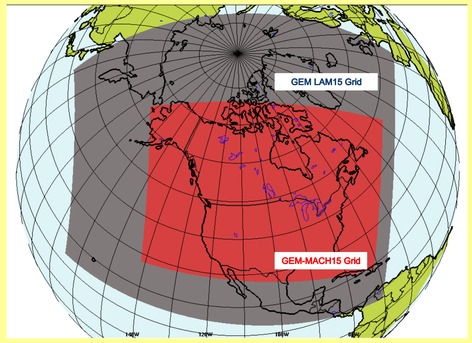
Abstract

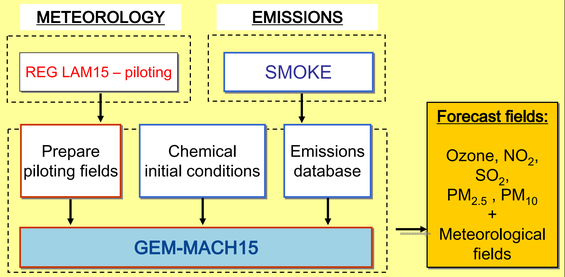
GEM-MACH was implemented by Environment Canada as a new multi-scale in-line air quality (AQ) forecast system in late 2009. The operational version, GEM-MACH15, is a limited-area model with 15-km horizontal grid spacing and 58 vertical levels extending from the surface to 0.1 hPa. The model is run twice daily at the Canadian Meteorological Centre in Montreal to produce 48-hour forecasts over a continental-scale domain.

This poster describes the operational performance evaluation of GEM-MACH15 predictions for a two-year period (Aug. 2009–July 2011). Model forecasts of O_3, $PM_{2.5}$, and NO_2 are compared against available surface measurements from Canada and the U.S. real-time monitoring networks. A selected statistical analysis is presented showing monthly and diurnal forecast performance for different regions across Canadian and U.S. Some model strengths and weaknesses are also identified.

1. Operational Air Quality Forecast Model: GEM-MACH15

GEM-MACH15 Model Configuration	
Grid Configuration	Limited Area Model (LAM) over North America
Grid Projection	Rotated Latitude-Longitude
Grid Dimensions	348 x 465 x 58
Horizontal Grid Spacing	15 km
Vertical Coordinate	58 Hybrid Levels
Model Top	0.1 hPa (~60 km)
Time Step	450 s for meteorology 900 s for chemistry
Emissions	Canada 2006, US 2012, Mexico 1999, BEIS v3.09 / BELD3
CPUs Execution Time	384 34 minutes for 48-h forecast
Model Output	Meteorology & Chemistry (gases and particles)





IMPLEMENTATION CHRONOLOGY

July 2009: GEM-MACH15 was delivered to Environment Canada's operational environment. Model output was used for internal evaluation only (not for public use);

November 2009: GEM-MACH15 officially became the new operational AQ forecast model in Canada (public version). 48 hour forecasts are made twice a day at 00 UTC and 12 UTC;

March 2010: A revised set of emissions files were introduced to solve a problem with PM2.5 over-prediction;

October 2010: Meteorological model supplying meteorological lateral boundary conditions was changed from a global variable-grid configuration of GEM15 to the limited-area REG LAM15;

October 2011: A new version of GEM-MACH15 (1.4.4) became operational, with updated dynamics and physics libraries, updated U.S. anthropogenic emissions (2012 projection), and updated biogenic emissions.

2. Evaluation Methodology

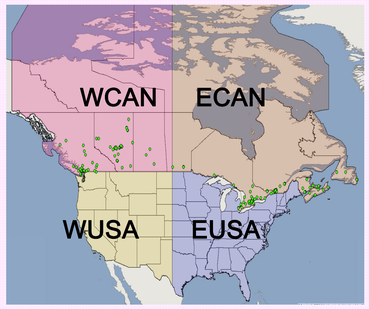
A new model performance evaluation package called ***VAQUM*** ("Verification of Air QUality Models") has been used to store measured and modelled station values and to calculate various evaluation metrics.

Evaluation period that was considered was the two-year period from 1 Aug. 2009 to 31 July 2011, where

Year 1 -> 1 Aug. 2009 to 31 July 2010
Year 2 -> 1 Aug. 2010 to 31 July 2011

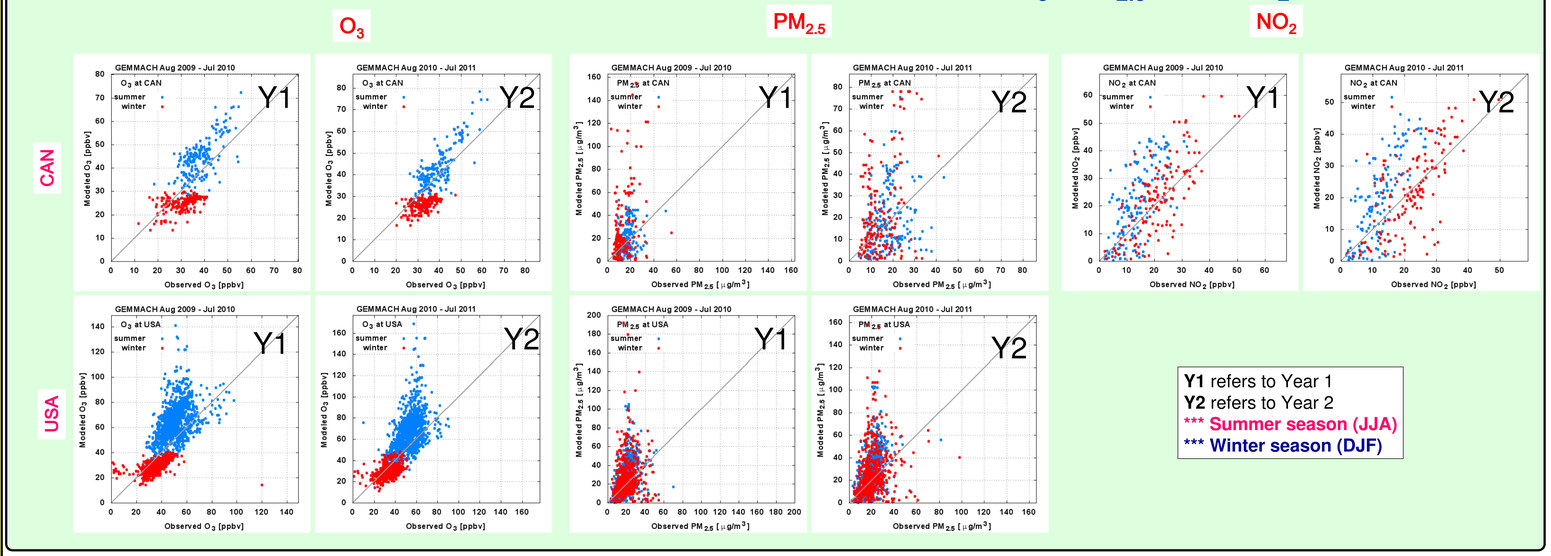
Number of measurement stations in Canada and USA

Country / Season	Ozone	PM2.5	NO2
Canada (summer)	184	170	134
Canada (winter)	182	171	133
USA (summer)	1,128	597	N/A
USA (Winter)	626	599	N/A

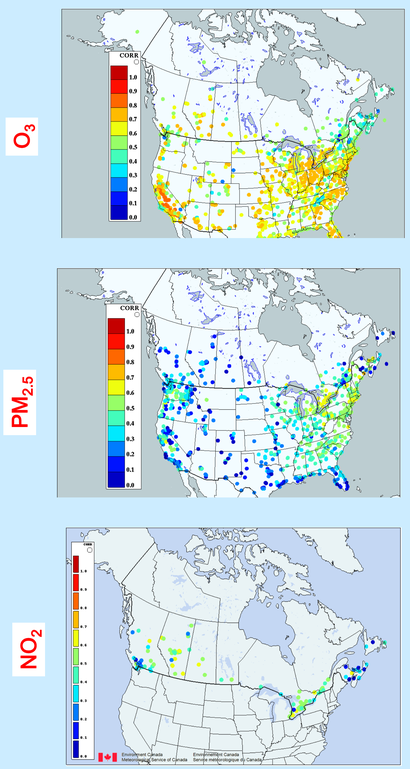


Quadrants used for regional analyses

3. Seasonal Scatter Plots (Predicted vs Observed) for O_3, $PM_{2.5}$, and NO_2

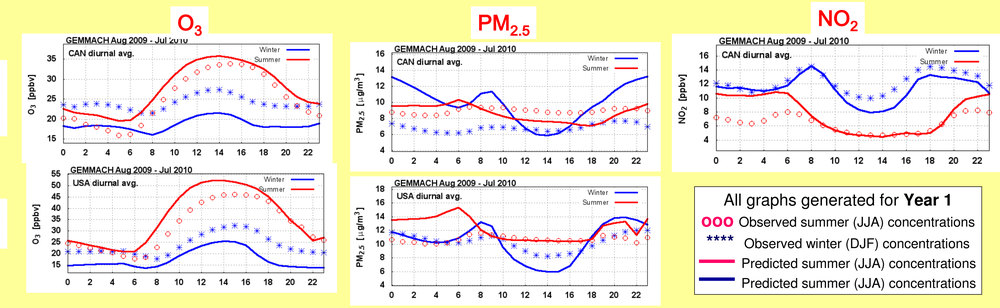


4. Annual Correlation Statistics based on Hourly Predictions

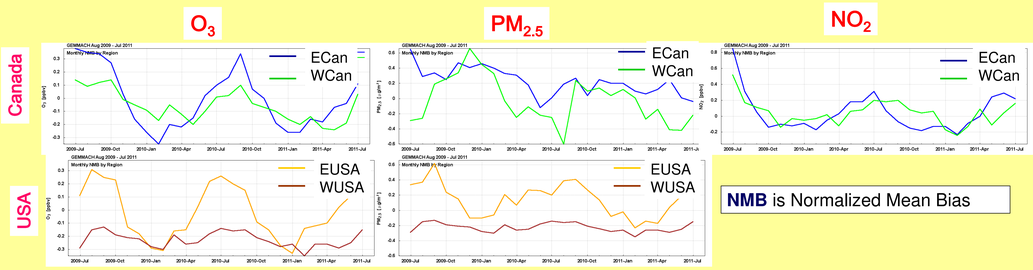


Correlations (R) based on Year 1

5. Diurnal Average by Season for O_3, $PM_{2.5}$, and NO_2



6. Monthly Variation of Regional Mean NMB for O_3, $PM_{2.5}$, and NO_2



7. CONCLUSIONS

The model's performance for the first two years of operation has been evaluated against surface observations from Canadian and U.S. monitoring networks. The model was able to reproduce well the seasonal, monthly, and diurnal cycle for O_3, $PM_{2.5}$ and NO_2. However, the model showed some weaknesses, especially in predicting $PM_{2.5}$ species. This analysis has helped us to plan future model improvements related to emissions, chemical parameterizations, and meteorology.